REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
8/2/96

3. REPORT TYPE AND DATES COVERED
Final Report

4. TITLE AND SUBTITLE
"Design and implementation of the tactor array controller tool"

5. FUNDING NUMBERS
ONR N00014-95-1-0526

6. AUTHOR(S)
Stanley J. Bolanowski

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Institute for Sensory Research
Merrill Lane
Syracuse University
Syracuse, NY 13244

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Department of the Navy
US Office of Naval Research
800 N Quincy Street
Arlington, VA 22217-5660

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Originally submitted 8/2/96

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

"Design and implementation of the tactor array controller tool." P.I. S.J. Bolanowski

The project was a contract for a piece of equipment to show feasibility of a system to improve situational awareness for pilots whose sensory systems are overtaxed or receiving conflicting information. The primary interest in developing such a device is to aid in decreasing the number of aircraft and pilots lost during warfare and while flying under conditions that corrupt situational awareness. The engineering project for which we were funded was derived from an Advanced Technology Demonstration Program (ATD) called the Tactile Advanced Technology Demonstration Program. Our portion of the project involved hardware and software design of a device to interface between the ouput of the gyroscope and the input to a tactor array. The tactor array consisted of tactors mounted on a body suit which the pilot wears. The gyroscopic information is fed into the controller which uses a lookup table, programmable via Labview software, and located in read-only-memory, to map orientation of the aircraft to particular patterns of vibration in the tactor array. The device was sent to NAMRL in Pensacola, FL, and was to be used in a flight test sometime in the middle of August, 1995.

14. SUBJECT TERMS

15. NUMBER OF PAGES
17

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT unclassified	20. LIMITATION OF ABSTRACT

GENERAL INSTRUCTIONS FOR COMPLETING SF 298

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to ***stay within the lines*** to meet ***optical scanning requirements***.

Block 1. Agency Use Only *(Leave blank)*.

Block 2. Report Date. Full publication date including day, month, and year, if available (e.g. 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g. 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume number, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C	-	Contract	PR	-	Project
G	-	Grant	TA	-	Task
PE	-	Program Element	WU	-	Work Unit Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency Report Number. *(If known)*

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with...; Trans. of...; To be published in.... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g. NOFORN, REL, ITAR).

DOD - See DoDD 5230.24, "Distribution Statements on Technical Documents."
DOE - See authorities.
NASA - See Handbook NHB 2200.2.
NTIS - Leave blank.

Block 12b. Distribution Code.

DOD - Leave blank.
DOE - Enter DOE distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports.
NASA - Leave blank.
NTIS - Leave blank.

Block 13. Abstract. Include a brief *(Maximum 200 words)* factual summary of the most significant information contained in the report.

Block 14. Subject Terms. Keywords or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

Block 16. Price Code. Enter appropriate price code *(NTIS only)*.

Blocks 17. - 19. Security Classifications. Self-explanatory. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED). If form contains classified information, stamp classification on the top and bottom of the page.

Block 20. Limitation of Abstract. This block must be completed to assign a limitation to the abstract. Enter either UL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.

FINAL REPORT

"Design and implementation of the tactor array controller tool." P.I. S.J. Bolanowski

The project funded by the Office of Naval Research is for the time period 3/1/9 to 12/30/95 with a total award amount (direct and indirect costs) of $96,733.00. Basically, the project was a one-time contract to design and build a specific piece of equipment to show feasibility of a system that would improve situational awareness for pilots and other Navy personnel whose sensory systems are overtaxed or receiving conflicting information (e.g., divers, astronauts, etc). The primary interest in developing such a device for the Navy is to aid in decreasing the number of aircraft and pilots lost during warfare and while flying under conditions that corrupt situational awareness (low to the ground, low velocity speeds in overcast conditions). The engineering project for which we were funded actually derived from an Advanced Technology Demonstration Program (ATD) called the Tactile Advanced Technology Demonstration Program. Our portion of the project involved hardware and software design of a device (controller) to interface between the output of a gyroscope and the input to a tactor array. The tactor array consisted of tactors (electromagnetic speakers and/or motors) that are mounted on a body suit which the pilot wears. The gyroscopic information (pitch and roll) is fed into the controller which uses a lookup table, programmable via Labview software and located in read-only-memory (ROM), to map orientation of the gyroscope (aircraft) to particular patterns of vibration in the tactor array. The device has was designed and built and sent to the Naval Air Medical Research Laboratory in Pensacola, FL, and was to be used in a test flight sometime in the middle of August., 1995.

Given the nature of the project we plan no publications, presentations, etc. regarding the controller-tool design. Standard fabrication processes were used (i.e., printed circuit boards) as were standard electronic and mechanical design principles. The attached Appendix contains documentation of the software and hardware of the array controller.

Appendix I. Tactor Array Application Tool Software

Appendix II. External hookup diagram, Power invertor connector schematic, gyro connector schematic, tactor connector pinout, ROM board layout, ROM board schematic, Synchro/resolver board schematic, speaker board driver schematic.

Tactor Array Controller Application Tool Software

Developed at the Institute for Sensory Research at Syracuse University,
Syracuse, New York 13244 USA.

Developed under contract from the Office of Navel Research
Grant # N00014-95-1-0526;R&T Project # 4237006---01;P.I. S.J. Bolanowski

ROM Pitch/Roll Translation Matrix Generator

Introduction

The software was developed using National Instrument's LabVIEW 3.1.1 full development package. The software design philosophy parallels that of LabVIEW in general. That is, a modular, graphic approach allows for rapid development and ease of modification of the translation matrix. Thus the ROM Pitch/Roll Translation Matrix Generator is both powerful and flexible to meet the needs of the investigator.

The software's primary function is to generate the binary code for translating real-time gyroscopic information from the aircraft's systems into a vibration pattern applied to the pilot's skin. The software allows for independent programming of 32 outputs with one of eight output states (three bits), or 32 outputs with on/off state (one bit) in response to 256 (2^8) pitch input states and 256 (2^8) roll input states for a total of 65536 (2^{16}) independent inputs.

Hardware Requirements

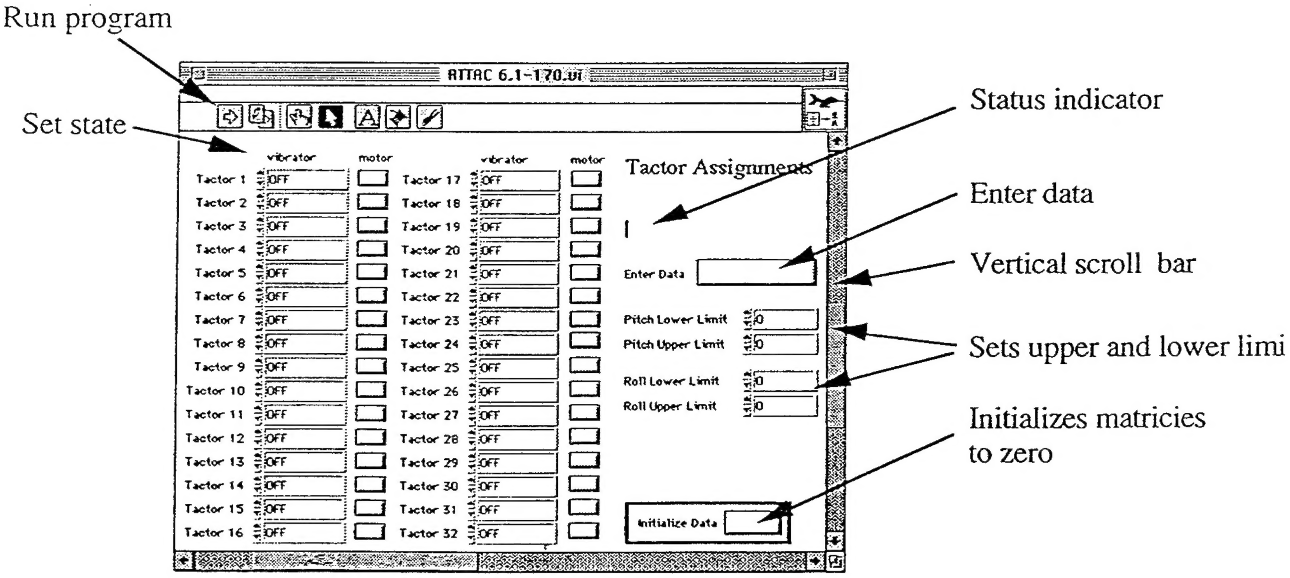
Since the software has been assembled as a application, LabVIEW 3.1.1 is not required to run it. However, modifications to the software will require the LabVIEW 3.1.1 full development package, the TAC-AT 1.0.vi file and the TAC-AT Library.llb (included on separate disks). The following hardware requirements are necessary for running the TAC-AT 1.0 application:

Processor:	68030 with math co-processor (68040 recommended)
	Power PC available (use ATTAC 6.1 PPC)
Hard Disk:	5 Mb free (each data set also requires an additional 1 Mb)
RAM:	10 Mb free **minimum**, 12 Mb recommended

Operation

To begin, decompress the TAC-AT 1.0 application using StuffIt™. Be sure that the default memory requirement in the Get Info window is set to at least 10 Mb (12 Mb recommended). Close the Get Info window and launch the TAC-AT 1.0 application.

Your screen should look similar to figure 1 depending on which version (development VI or application) of the program you are running.



	vibrator	motor		vibrator	motor
Tactor 1	OFF	□	Tactor 17	OFF	□
Tactor 2	OFF	□	Tactor 18	OFF	□
Tactor 3	OFF	□	Tactor 19	OFF	□
Tactor 4	OFF	□	Tactor 20	OFF	□
Tactor 5	OFF	□	Tactor 21	OFF	□
Tactor 6	OFF	□	Tactor 22	OFF	□
Tactor 7	OFF	□	Tactor 23	OFF	□
Tactor 8	OFF	□	Tactor 24	OFF	□
Tactor 9	OFF	□	Tactor 25	OFF	□
Tactor 10	OFF	□	Tactor 26	OFF	□
Tactor 11	OFF	□	Tactor 27	OFF	□
Tactor 12	OFF	□	Tactor 28	OFF	□
Tactor 13	OFF	□	Tactor 29	OFF	□
Tactor 14	OFF	□	Tactor 30	OFF	□
Tactor 15	OFF	□	Tactor 31	OFF	□
Tactor 16	OFF	□	Tactor 32	OFF	□

Tactor Assignments

1

Enter Data □

Pitch Lower Limit 0
Pitch Upper Limit 0
Roll Lower Limit 0
Roll Upper Limit 0

Initialize Data □

Figure 1

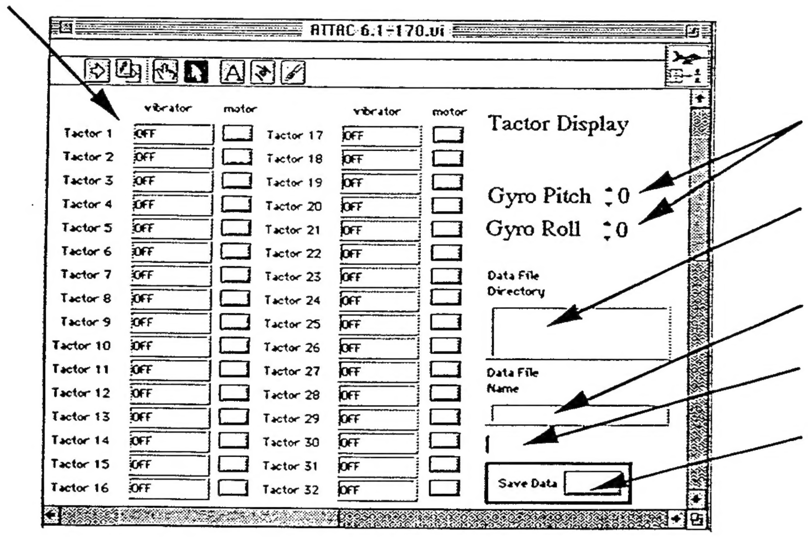
At the beginning of your programming session, press the Initialize Data button BEFORE you run the program. This will set the matrices to zero and assign the proper amount of memory to the ROM data sets. You can now start and stop the execution of the program without changing the data set. If you wish to reset the data, stop the program, press the Initialized Data button and then run the program. This will reset the data to zero and initialize the data matrices. Set the upper and lower limits of the pitch and roll values you wish to program. For example, set the limits to

pitch lower limit	=	-5
pitch upper limit	=	5
roll lower limit	=	0
roll upper limit	=	0

and set Tactor 1 to Oscillator 1. Press Enter Data to write the tactor assignments to the data matrices in memory.

Using the vertical scroll bar, slide up to the Tactor Display area. Your screen should look similar to the figure 2.

Indicates state



ATTAC 6.1-170.vi

	vibrator	motor		vibrator	motor
Tactor 1	OFF	□	Tactor 17	OFF	□
Tactor 2	OFF	□	Tactor 18	OFF	□
Tactor 3	OFF	□	Tactor 19	OFF	□
Tactor 4	OFF	□	Tactor 20	OFF	□
Tactor 5	OFF	□	Tactor 21	OFF	□
Tactor 6	OFF	□	Tactor 22	OFF	□
Tactor 7	OFF	□	Tactor 23	OFF	□
Tactor 8	OFF	□	Tactor 24	OFF	□
Tactor 9	OFF	□	Tactor 25	OFF	□
Tactor 10	OFF	□	Tactor 26	OFF	□
Tactor 11	OFF	□	Tactor 27	OFF	□
Tactor 12	OFF	□	Tactor 28	OFF	□
Tactor 13	OFF	□	Tactor 29	OFF	□
Tactor 14	OFF	□	Tactor 30	OFF	□
Tactor 15	OFF	□	Tactor 31	OFF	□
Tactor 16	OFF	□	Tactor 32	OFF	□

Tactor Display

Gyro Pitch 0

Gyro Roll 0

Data File Directory

Data File Name

Save Data

Pitch and Roll Settings

File directory path

ROM data file name

Error messages

Save data

Figure 2

Now change the Gyro Roll to 0 and change the Gyro Pitch values from -10 to +10. Observe the state of Tactor 1 as you change the pitch values. The state should change from "OFF" to "Tactor 1" and then to "OFF" again as you pass through the lower and upper pitch limits previously assigned.

To Write ROM Data to Disk

In the Data File Directory, enter the path name for the data files (e.g. Hard Disk:Data Folder) and enter the name for the data files in the Data File Name box (e.g. Test Data Set). When you have finished assigning tactor states to pitch and roll limits, press the Save Data button and sixteen files, one for each ROM, named *filename*.ROM # will be written to the folder in the Data File Directory. The Suffix ROM# will be appended to the data file name where # is the ROM designator from 0 hex (0 dec) to F hex (15 dec). The data files are a byte streams of 65537 unsigned 8-bit words. the first byte in the file designated the ROM (0 to F) and the next 65536 bytes (64k bytes) are the code for the tactor assignments.

To Write Data to ROM

Launch the "Rom Burn" application. (See Rom Burn READ ME file for instructions).

Appendix

Tactor Coding

Each ROM has a 16-bit address input and an 8-bit data output. Each ROM can control two tactors or two motors with the code shown in figure A1.

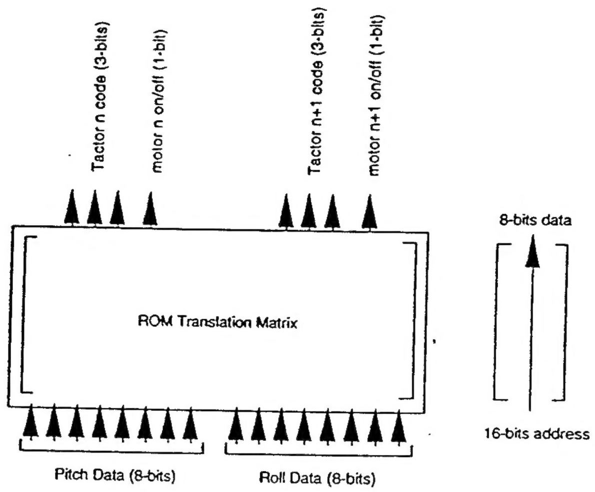


Fig A1

Rom Burn README file

Menu Choices

Burn One ROM

This will bring up the standard open file dialog, allowing the user to select a file. The file will be read, the user will be asked if the label on the ROM agrees with the file's internal identification number, and then the ROM will be programmed.

Burn All ROMs

The standard file open dialog is displayed, the user picks a file (any ROM file).
The program then identifies a **sequence** of ROM files, using the ".ROM x"n extension of the chosen file. ROMs 0-F (0,1,2,3...9,A,B,C,D,E,F) of this seris will be programmed, with the user prompted for swapping a ROM out, and placing the next ROM in.
Any errors in downloading or burning will be detected and the sequence halted.
The sequence is always started at zero, it is irrelevant which file is chosen.
Note that ALL of the files must be in the same folder.

Echo output to screen.

The download information is echoed to the window as it is being sent to the burner.
This choice toggles on and off, with a check mark meaning on

Quit

This quits the program.

The ROM burner must be attached to the serial port.
no other programs should be running which also use the serial port, such as communication programs, or netmodem control panels, as these may interfere with operation, as some of them tie up the serial port whenever running, instead of when a document is open.

Status & Error Messages.
various messages will be scrolled in the window while the program is operating.

Common Messages:

ROM:n File:name.ROM n Displayed when a file is opened in Burn All mode.

Downloading nnn sec:_______ Displayed as data is sent to burner unit. The horiztontal line shows progress.

Data Uploaded. 5sec. Timeout wait. The burner needs a timeout to recognize the data end.

Program nn sec:________ Displayed while unit is burning ROM. The line shows progress. (done when lower line reaches end of upper)

***** Successful Burn ***** ROM succesfully burned in.

***** No ROM in burner ***** as it says. perhaps it is incorrectly positioned.

***** ROM is not blank ***** only blank or erased ROMs may be burned.

Stopped at ROM n The mentioned ROM did NOT get burned in a attempt to burn all roms. Some other error will be mentioned above this.

Uncommon Error Messages

***** ROM did not program ***** internal burner error, try again.

***** ROM programmed, did not verify ***** try erasing, then re-try or use new ROM.

Burner didn't read Program command!! internal burner error, try power-cycle.

*****Not a ROM file.***** the selected file is not a ROM file.

Problem found during data read. The file does not contain enough data for a ROM.

Problem found during ROM ID read. The file is empty. Perhaps an aborted file copy?

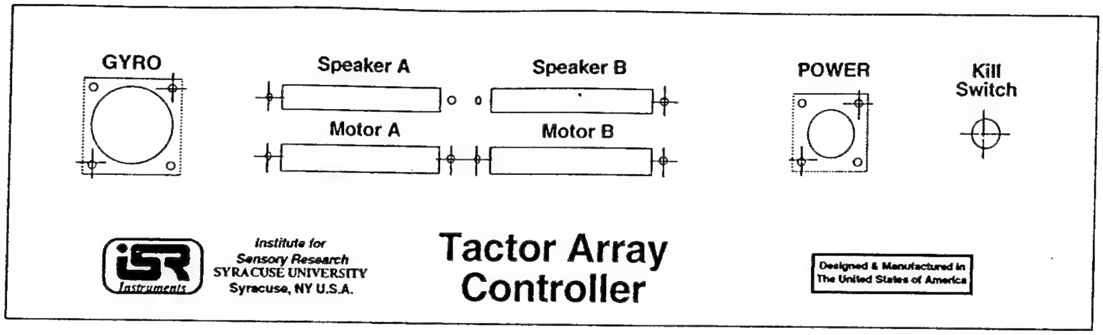
User cancelled. operation was cancelled by user in dialog

File internal ID doesn't match filename ID The ROM id# of file NAME does not match the id# stored in the file! perhaps it has been re-named?

Burner returned Invalid Type:[%s] a incorrect ROM type has been selected on the burner's front panel. the type selected should be 27512(12int)

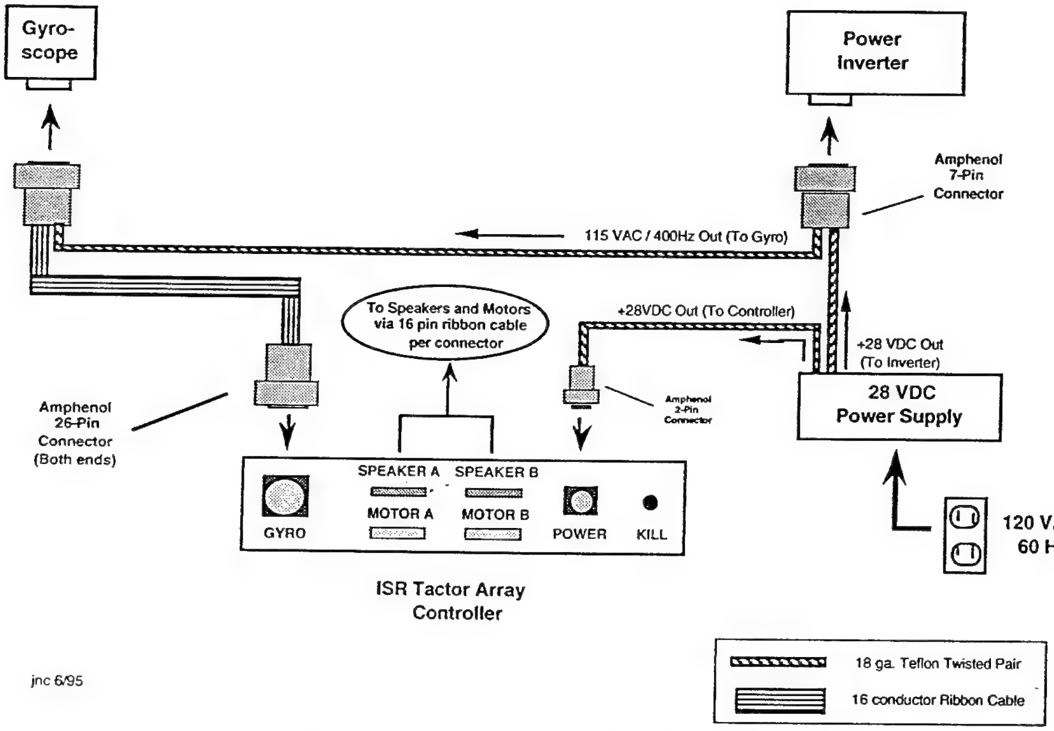
Attempting Reset..
Reset failed, set at:%s
Burner reconfigure success.

These three messages have to do with resetting the burner's power-on state if it somehow gets scrambled. If the 'Reset failed' message appears it means the burner is seriously damaged.



Front Panel layout

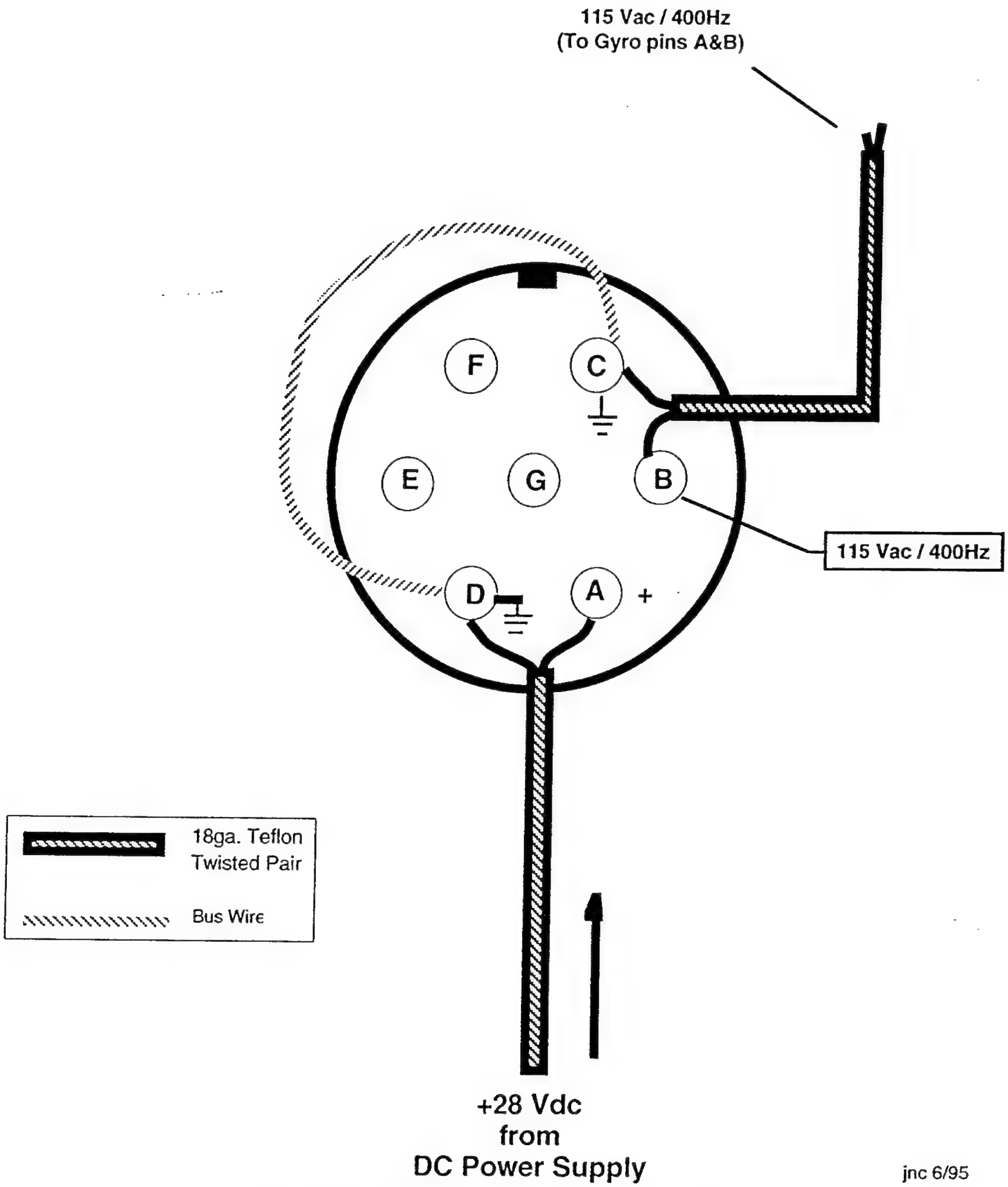
Gyroscope / Power Inverter / Tactor Array Controller
Interconnect Scheme


Gyro-scope
Power Inverter
Amphenol 7-Pin Connector
115 VAC / 400Hz Out (To Gyro)
To Speakers and Motors via 16 pin ribbon cable per connector
+28VDC Out (To Controller)
+28 VDC Out (To Inverter)
28 VDC Power Supply
Amphenol 26-Pin Connector (Both ends)
Amphenol 2-Pin Connector
SPEAKER A
SPEAKER B
MOTOR A
MOTOR B
GYRO
POWER
KILL
ISR Tactor Array Controller
120 VAC 60 Hz
jnc 6/95
18 ga. Teflon Twisted Pair
16 conductor Ribbon Cable

Overall External Hookup Diagram

Pinout of Amphenol 7-pin connector (connects to Power Inverter)

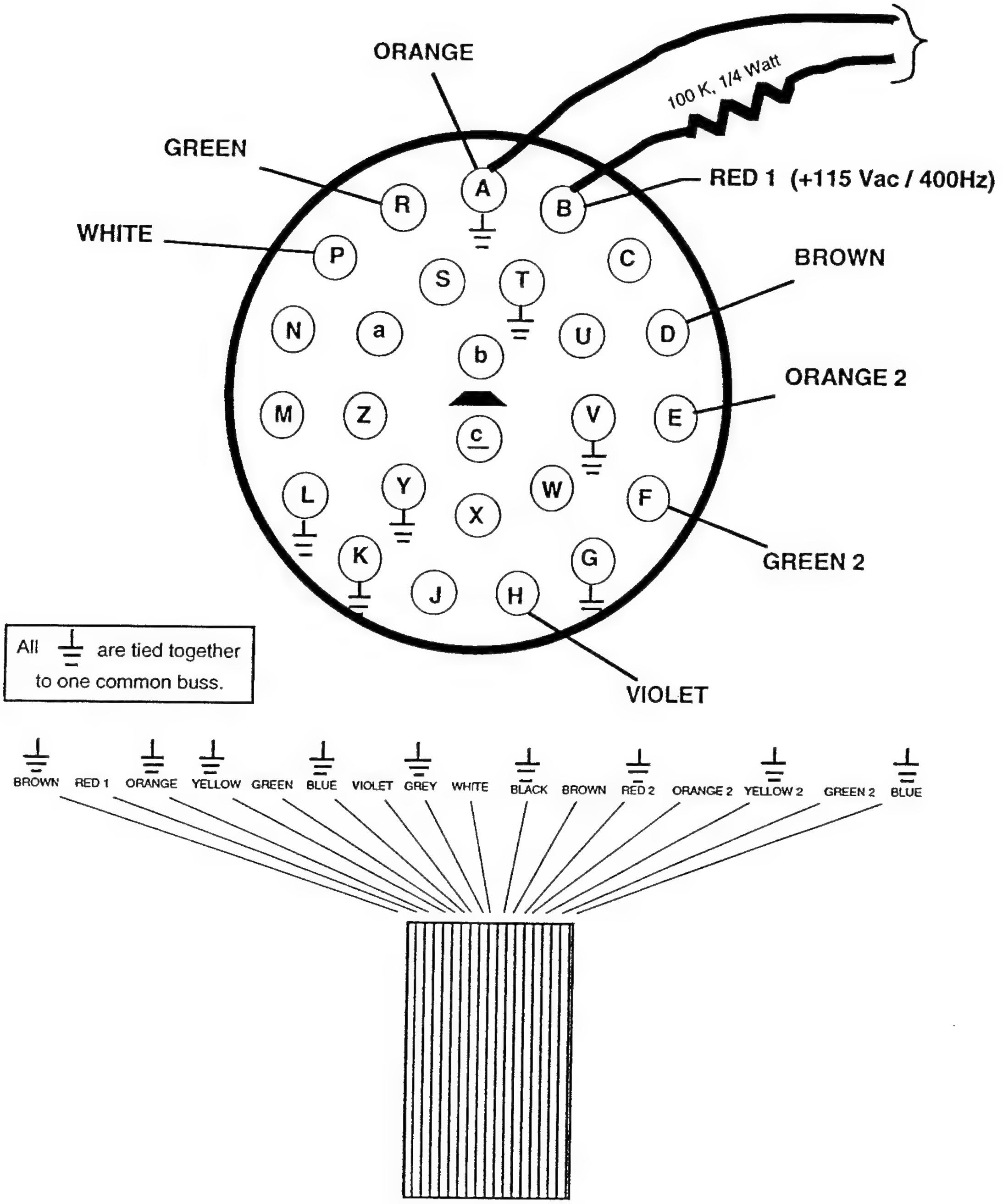
SOLDER-SIDE VIEW



jnc 6/95

Power Invertor Connector Schematic

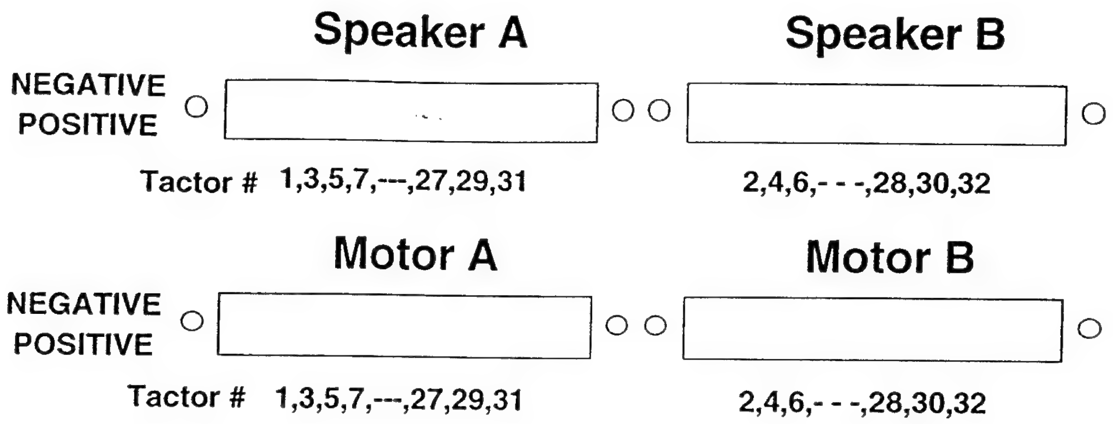
Pinout of 26-pin Amphenol connector (connects to Gyroscope)
SOLDER-SIDE VIEW



STANDARD 16-CONDUCTOR RIBBON CABLE

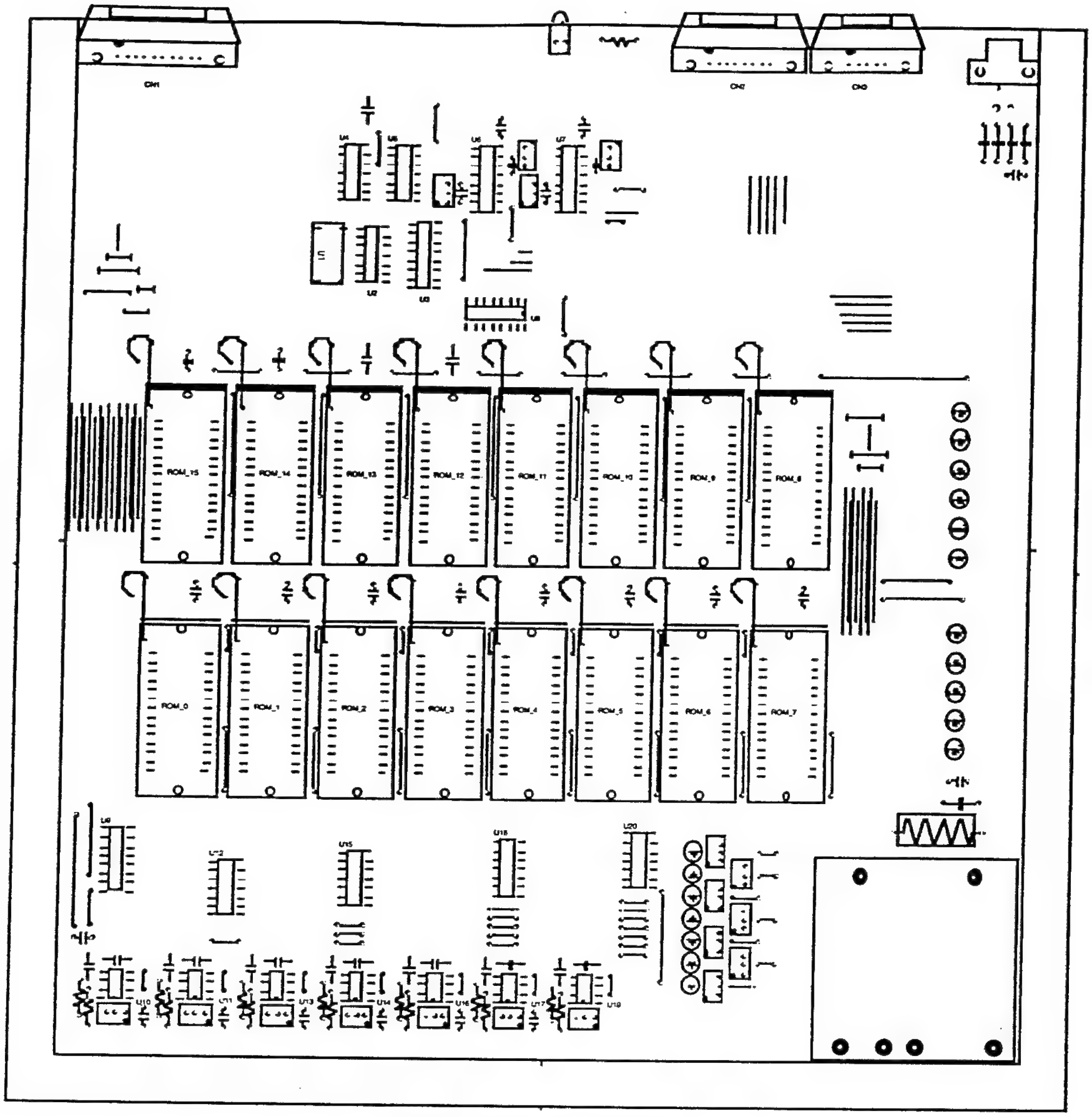
jnc 6 / 95

Gyro Connector Schematic

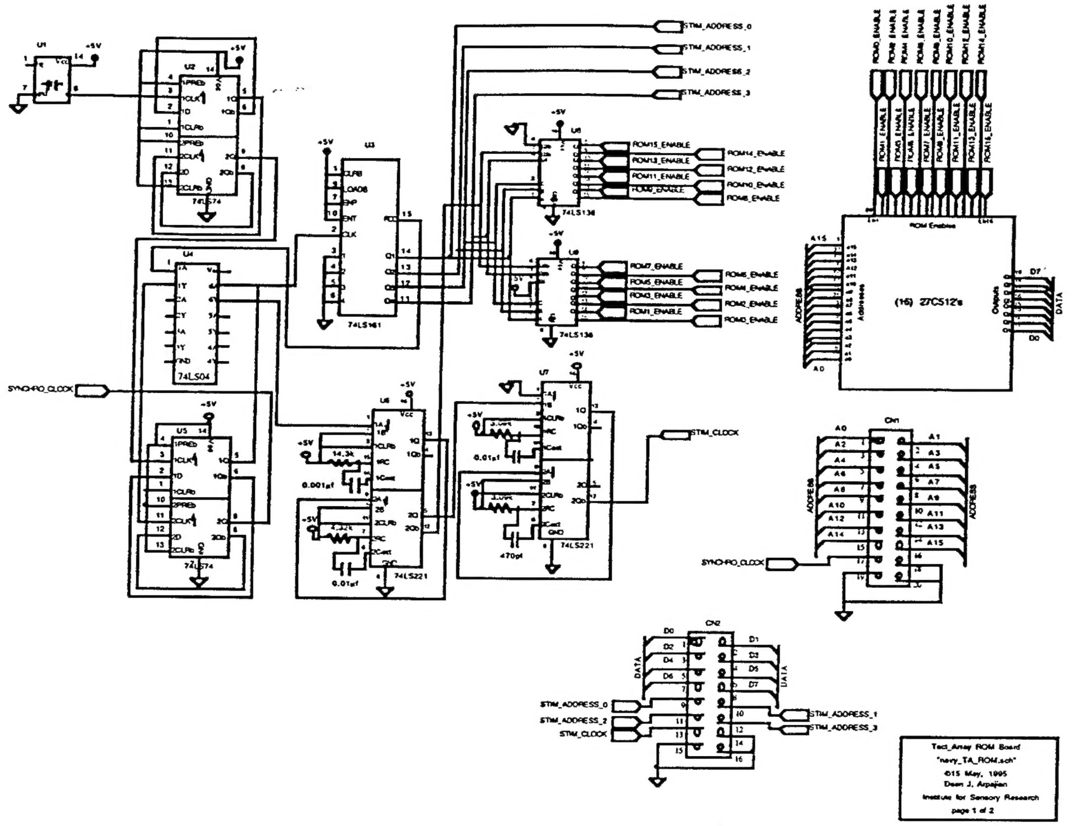


NOTE: Use 34 pin ribbon connectors
Pins 33 and 34 are unused

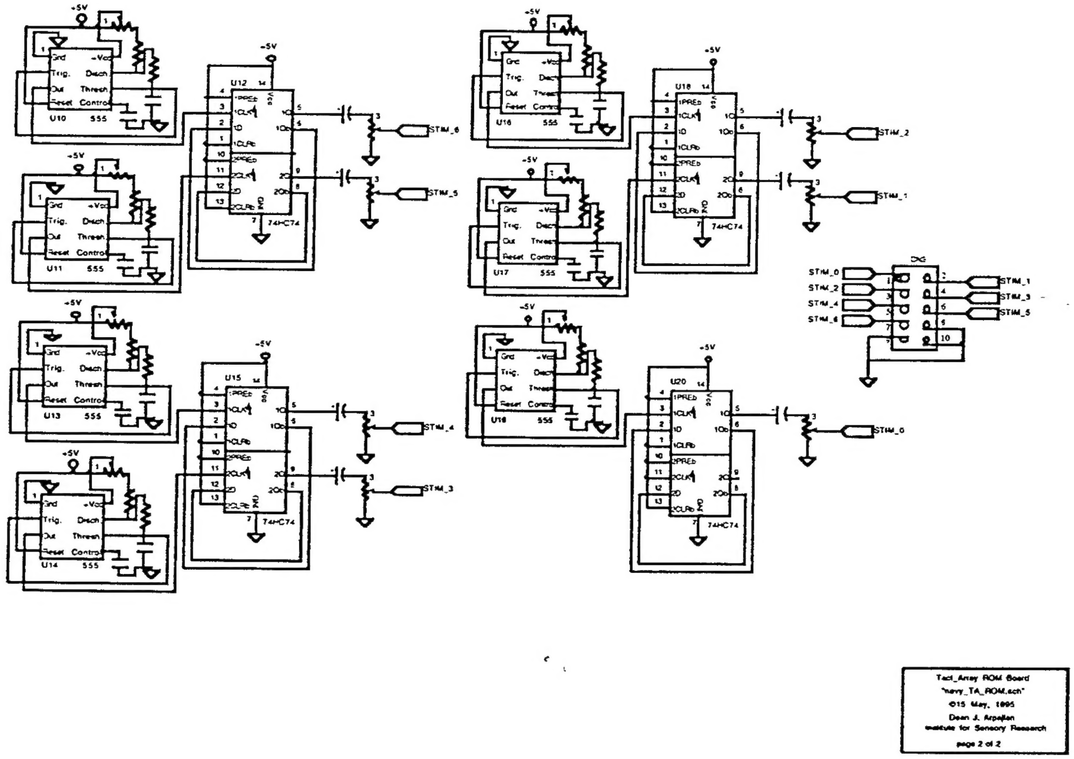
Tactor Connector Pinouts



ROM Board Layout

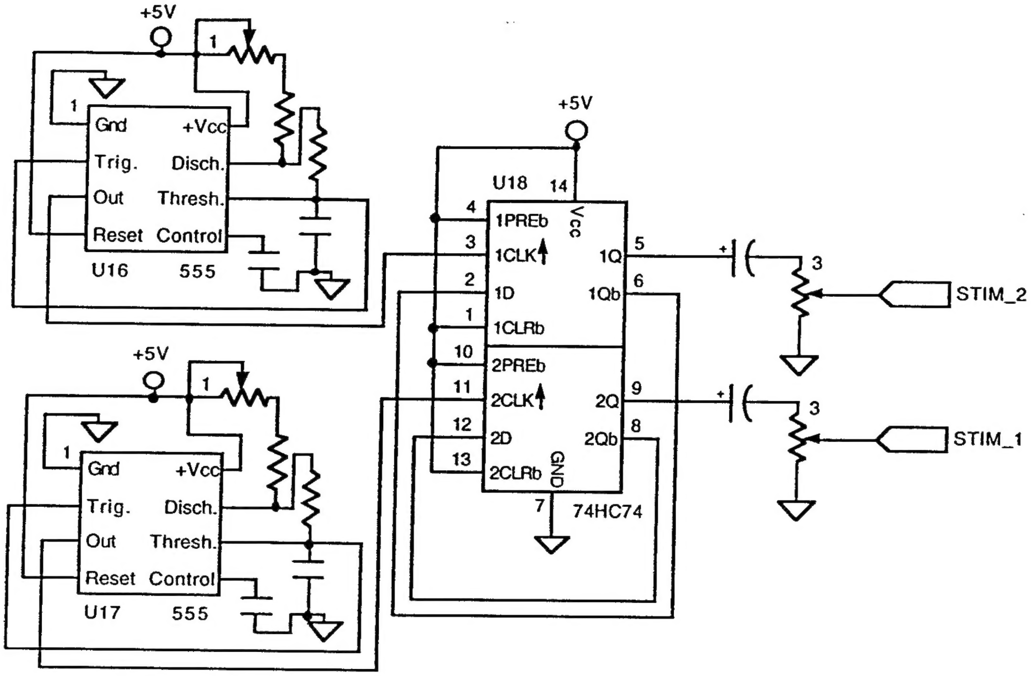


1 of 2 ROM Board Schematic

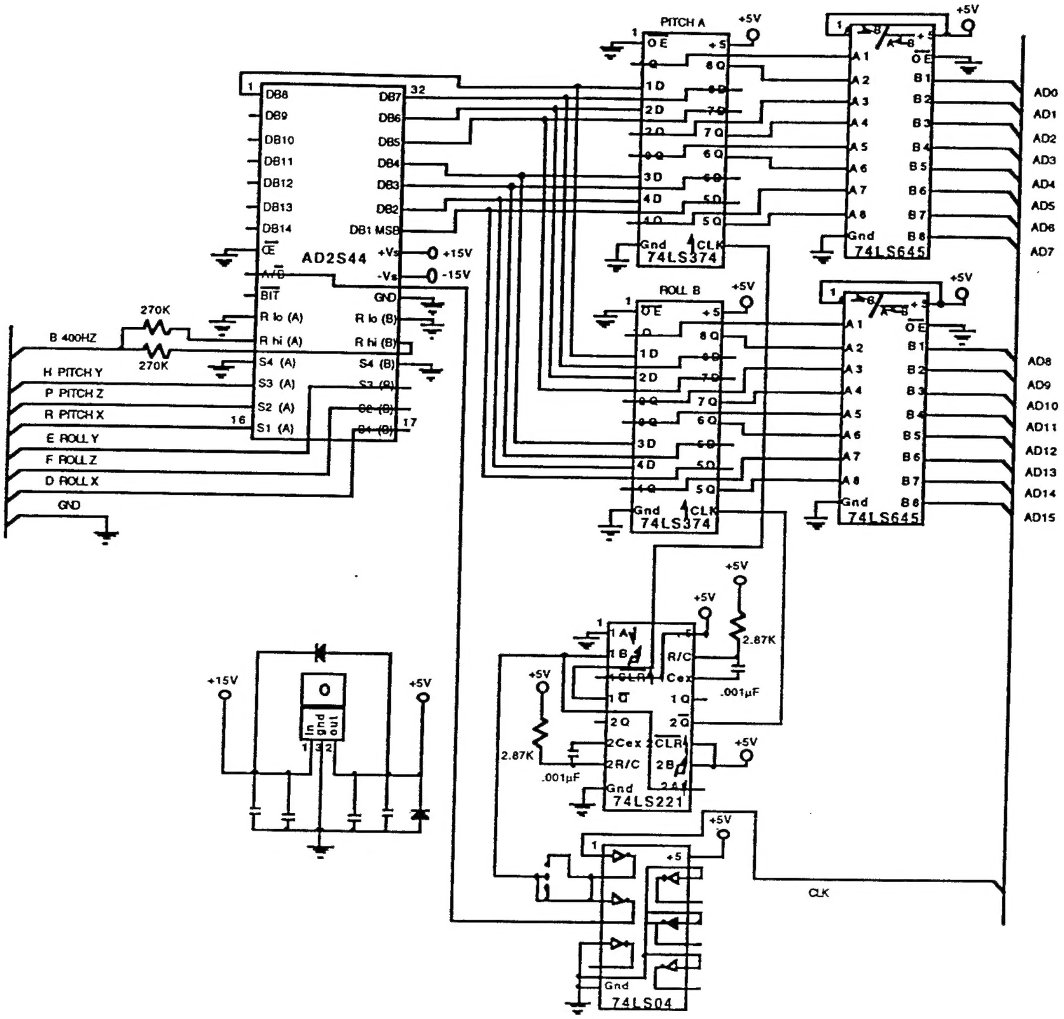


2 of 2 ROM Board Schematic

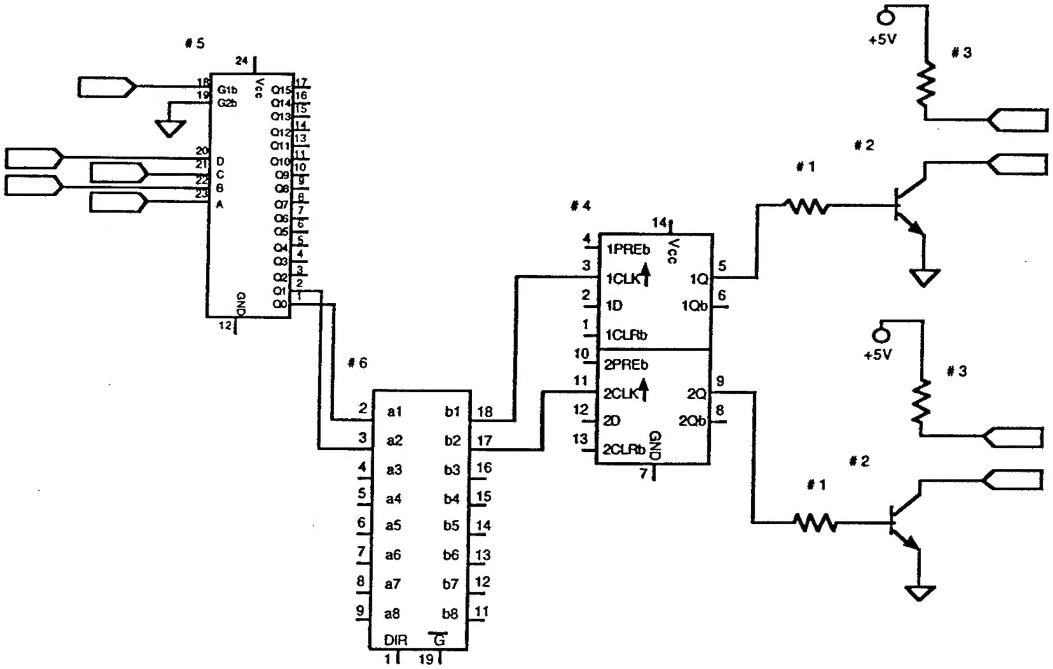
A2.6



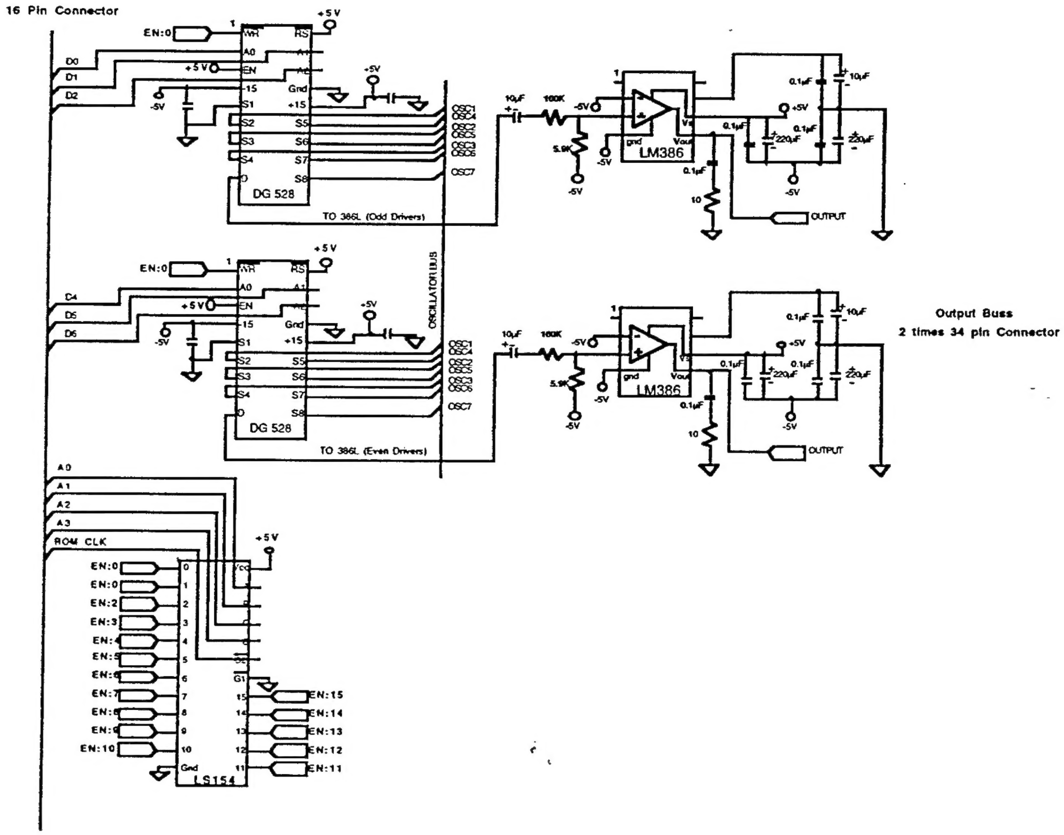
2 of 2 ROM Board Schematic (555 Timer Blow Up)



Synchro / Resolver Board Schematic



Motor Driver Board Schematic (NOT Complete)



Speaker Driver Board Schematic